Central London Rail Study

A joint study by
The Department of Transport
British Rail Network SouthEast
London Regional Transport
London Underground Ltd

January 1989

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CENTRAL LONDON RAIL STUDY

Secretary of State's Preface

London's economy has been growing strongly in recent years. This growth is expected to continue. More and more people are seeking to come to work in the tightly packed central area. Parts of Inner London, most notably Docklands, are being transformed. In Outer London, the general revival in the national economy has contributed to sharp increases in traffic levels. All this is putting severe strains on London's transport system, which is suffering from heavy congestion at peak times, on both road and rail.

It was against this background that I set up the Central London Rail Study in March 1988. The Study has been conducted jointly between my Department, British Rail, London Regional Transport, and London Underground. A group under my Chairmanship, including the Chairmen of British Rail and London Regional Transport, has agreed that its findings should now be published.

The Report calls for a major upgrading programme of the existing rail networks for which there is already some provision in present plans. This will provide an early response to some of the most pressing problems. The Study also identifies two major options for substantial additions to London's rail infrastructure, as a full response to the continuing problems that are likely to be with us in the longer term. Both involve the construction of two new railway lines in tunnels under central London.

Some of the assumptions and estimates which underlie this Report can only be tentative at this stage. Before decisions can be taken on whether to go ahead with the very large investments that are proposed, these estimates will have to be refined. Further work is also necessary on how such investments could be financed. The Government believes that, if there is to be new investment in transport in London, the passengers, who will benefit, should meet the cost of it through the fares they pay, rather than be subsidised by taxpayers in the rest of the country.

Contributions should also be forthcoming from property owners and developers who stand to gain from the improvements to transport. Where these two sources of finance are not enough to make a project commercially viable, Government grant may be available provided the economic benefits, for example in the relief of road congestion, are sufficient to justify it.

I believe this Report is a major step forward in meeting London's transport needs. Interested parties are being asked to give their views on the proposals in this document, and to state their preferences. In the light of these and the further detailed work that remains to be done, I hope to be in a position to take decisions on the way ahead later this year.

Paul Channon

1.0 TERMS OF REFERENCE

1.1

The terms of reference for the Study were as follows:

- To develop a strategy for improving services for passengers on the British Rail and Underground networks in London, and to provide for forecast demand on the two networks up to the end of the century, with particular reference to passenger congestion in the area bounded by the major rail termini and their approaches.

- To have regard to the need to make the best use of existing assets.

- To put forward packages of measures, at different forecasts of demand, whose costs are justified in terms of revenues, demonstrating the extent to which proposed improvements could be financed from fares, and where necessary taking account of quantified external benefits.

- To present the strategic choices.

In this report, the Study team outlines its analysis of these issues and identifies some promising schemes. The next phase of work, to be completed by July 1989, will bring the analysis of schemes to the point where the Government and the railway operators will be in a position to take the necessary decisions.

2.0 PAST TRENDS AND PRESENT PROBLEMS

2.1 Recent Trends

Since 1982, there has been a substantial increase in the number of morning peak period passengers entering central London by rail as the adjacent table and Figure 1 show:

thousands of passengers

	1980	1983	1987	1988*
Underground	305	323	403	415
British Rail	412	384	449	468
	717	707	852	883

* provisional

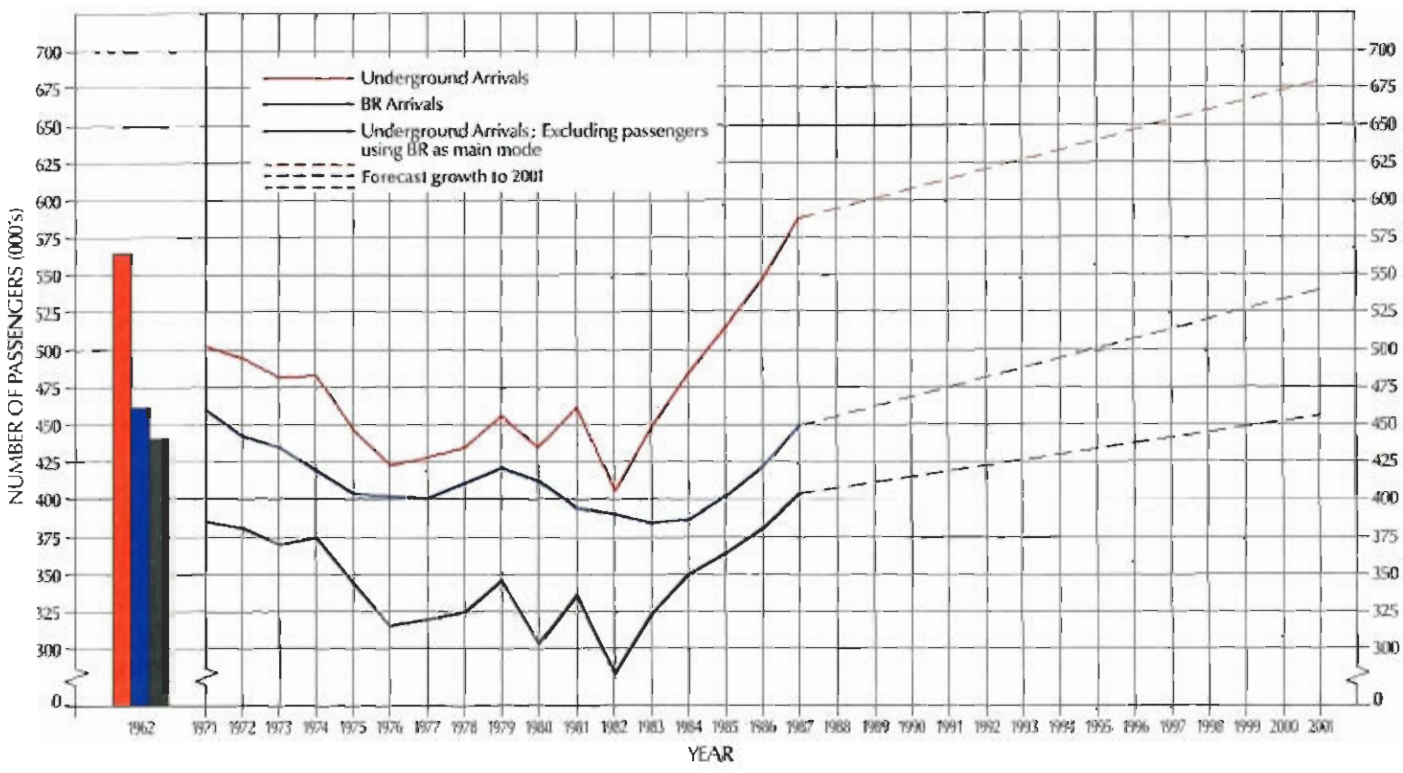
Approximately half of the morning peak passengers arrive in London between 8 and 9 o'clock. Both London Underground and British Rail services are now carrying record numbers of passengers into central London. In addition, the Underground today distributes some 200,000 British Rail passengers within central London, some 50% more than in 1983.

Some of this growth has been at the expense of bus, coach, car and cycle traffic, which have all declined in the last few years, but there has also been a general increase in commuting to central London of some 100,000 people per day.

The result has been to place the existing rail system, particularly the Underground, under increasing pressure. On Network SouthEast, the tendency for growth to be focused on longer distance commuting from beyond the Greater London boundary has also led to acute problems on certain services.

FIGURE 1
PAST TRENDS AND FORECAST GROWTH IN RAIL COMMUTING

ARRIVALS AT CENTRAL LONDON STATIONS BY RAIL IN MORNING PEAK PERIOD (0700-1000) 1962, 1971 to 1987 AND FORECAST GROWTH TO 2001
(1962 marks highest previous recorded level)



2.2 Overcrowding on the Underground

Whilst off-peak demand has grown by 80% or more since 1980, the major challenge facing the Underground is coping with the 35% growth in peak traffic over this period. Figure 2 (page 6) shows the sections of the network which were above the Underground's "planning standard" in 1987. This is, broadly, that on average over the busiest peak hour no more than one person should have to stand for each seated passenger.

2.3 Overcrowding on British Rail

Network SouthEast's planning standards recognise that most British Rail journeys are longer than those on the Underground. The standards are that no passenger should have to stand for over 20 minutes and that no more than 35 passengers should have to stand for every 100 seated on sliding-door stock and no more than 10 should have to stand for every 100 seated on slam-door stock. Figure 2 (page 6) shows the sections of the network which exceeded these standards in 1987.

2.4 Congestion at Stations and Interchanges

As well as overcrowding on trains, congestion at stations is now a major problem. At some 25 Underground stations, serious congestion is already occurring at peak periods, either in the ticket hall, on lifts or escalators, or at platform level. A further 10-15 stations will become seriously congested by the end of the century if demand continues to grow as forecast.

British Rail stations, being generally above ground and more spaciously designed, do not suffer from severe congestion to the same extent. However, a shortcoming of the London rail network is that nearly all Network SouthEast services terminate at stations on the edge of the central area, where many passengers change onto the Underground or buses. These stations are amongst the most congested on the network and are also served by the most crowded Underground lines.

More Underground stations will become seriously congested as demand continues to grow.

Some British Rail terminal stations are amongst the most crowded on the network.

3.0 FUTURE PROSPECTS

3.1 Future trends: planning assumptions

***The Broadgate development is helping to** finance the reconstruction of the Liverpool Street stations.*

employment growth 1987 to 2001

	Lower projection	Higher projection
Central London	+ 100,000	+ 150,000
Docklands (Newham and Tower Hamlets only)	+ 120,000	+ 150,000
	+ 220,000	+ 300,000
Rest of London	+ 60,000	+ 120,000

Traffic congestion in central London.

In order to evaluate major schemes against a backcloth that reflects likely travel patterns in the future, the Study developed a view of how London's economy and employment patterns are likely to evolve up to the turn of the century (2001).

The demographic forecasts have been taken from published projections developed by the London Research Centre. These imply, broadly, little change in London's population overall – though with significant growth in Docklands. The Study assumes a 2% per annum growth in GDP per head and growth in car ownership of some 20% by the turn of the century. Real fare levels are assumed to move in line with GDP.

A crucial element of the planning assumptions is the view taken of the scale of employment growth in central London and Docklands, and of where new employees will live. Two employment growth projections have been adopted as the adjacent table shows.

For the present Study, the critical element is the substantial growth expected in central London employment. Work has concentrated on the lower projection and, except where otherwise stated, all the estimates and forecasts in this report relate to that projection.

Whilst more jobs are expected to be created in Docklands, the problems facing the rail network serving central London are more acute, as many of the corridors feeding into central London are already severely congested, and, unlike the Docklands Light Railway, cannot readily be upgraded to take substantially higher traffic. The detailed implications of the growth in Docklands are being assessed separately in the East London Rail Study. This is examining the best options for improving rail access to Docklands from central London and East Thameside including those canvassed in the Docklands Access Consultation Document (on which London Regional Transport and the London Docklands Development Corporation are currently seeking views) and the proposal put forward by Olympia and York for a new underground Line from Waterloo to Greenwich. The East London Rail Study is being conducted by Consultants for the Departments of Transport and Environment and London Regional Transport.

The place of residence of workers has also been reviewed. In line with past and current trends, further substantial growth in commuting from outside London has been assumed with long-distance commuting projected to grow by some 30-40%, whereas the number of workers living inside London is only expected to grow by some 7%.

3.2 Traffic Growth Forecasts

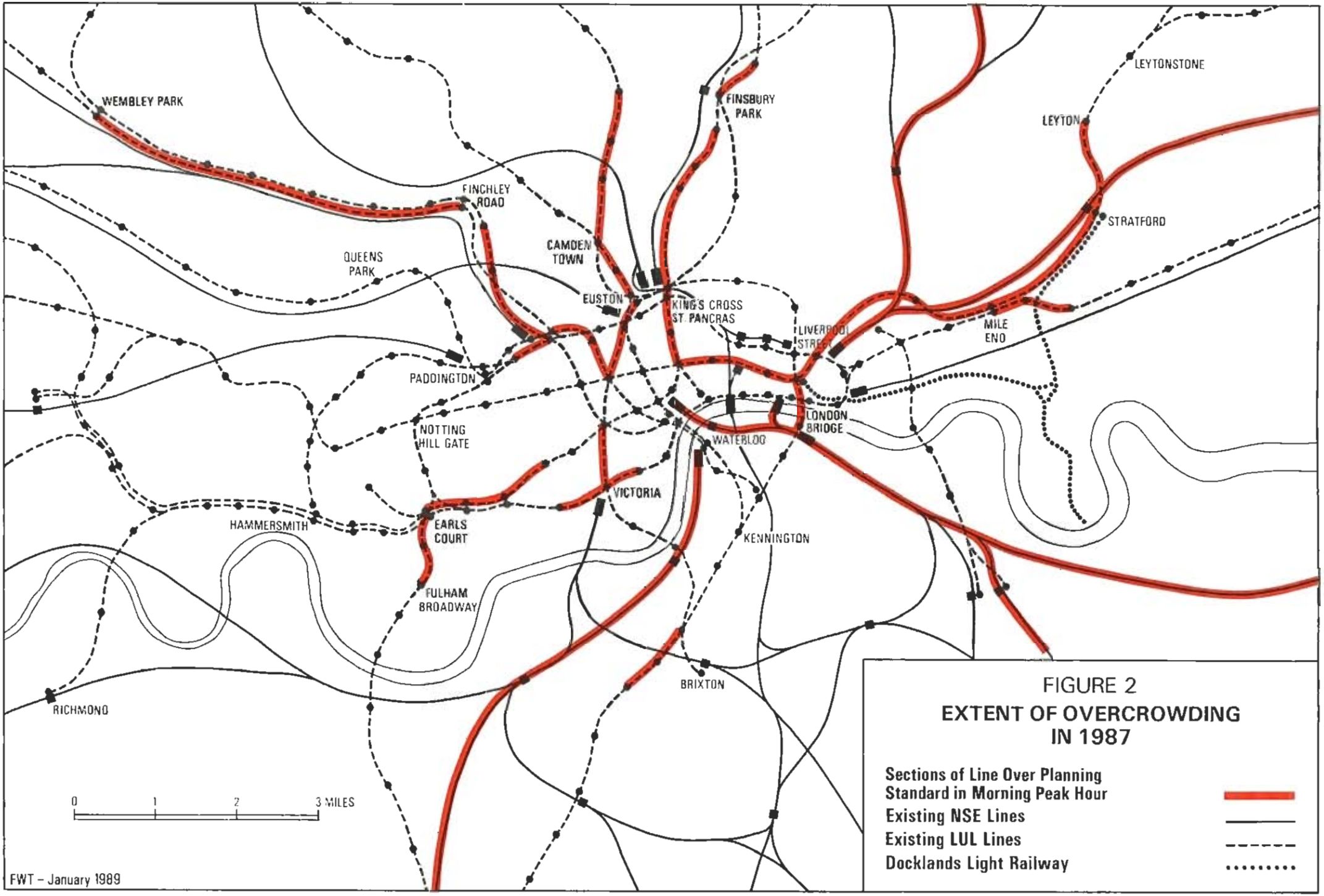
The implications of the planning assumptions (and of the major schemes described later in the report) have been explored using the strategic model developed following the 1981 Greater London Transportation Survey. This "LTS model" is currently maintained for the Department of Transport by the MVA Consultancy. Where necessary in assessing schemes, use has also been made of data derived from the operators' passenger origin-destination surveys.

Tests using the LTS model indicate that with only the lower employment projection plus the other assumptions outlined above, travel by both road and rail is likely to increase substantially by 2001. London-wide car traffic is forecast to increase by some 10% in the morning peak.

Morning peak rail traffic entering central London is forecast to increase by some 15% with BR trips growing by nearly 20% and Underground trips by about 13%. In addition Underground trips from BR stations within the central area are forecast to increase by 20% during the morning peak. The attraction of Docklands as an employment centre is expected to moderate the growth of commuting by Underground from the east to central London. At the same time, the number of passengers crossing central London to reach Docklands is forecast to increase.

3.3 Highway Network and Docklands Infrastructure Assumptions

A substantial programme of investment in roads has been assumed. This includes the proposed upgrading of the North Circular Road, the construction of the East London River Crossing and a new road network in Docklands. Extensions of the Docklands Light Railway to Bank, Beckton and Lewisham are assumed with increased frequencies and capacities.


WEMBLEY PARK
FINCHLEY ROAD
QUEENS PARK
CAMDEN TOWN
FINSBURY PARK
LEYTONSTONE
LEYTON
STRATFORD
EUSTON
KING'S CROSS ST. PANCRAS
LIVERPOOL STREET
MILE END
PADDINGTON
NOTTING HILL GATE
LONDON BRIDGE
WATERLOO
VICTORIA
HAMMERSMITH
EARLS COURT
KENNINGTON
FULHAM BROADWAY
BRIXTON
RICHMOND
0 1 2 3 MILES
FIGURE 2
EXTENT OF OVERCROWDING IN 1987
Sections of Line Over Planning Standard in Morning Peak Hour
Existing NSE Lines
Existing LUL Lines
Docklands Light Railway
FWT – January 1989

4.0 MAKING THE MOST OF THE CURRENT NETWORK

4.1 Major Upgrading Programme

Prototype Central Line train on test.

The Study has considered the extent to which present and forecast demand can be catered for by increasing the effectiveness and capacity of the existing network without building new lines or extensions. It is clear that a "Major Upgrading Programme" consisting of the following items could make a substantial contribution to relieving congestion:

- improvements to increase Underground station capacity
- investment to secure better operating performance
- more trains
- higher capacity trains
- restructuring of services.

4.1.1 Improvements to increase Underground station capacity

An estimate of some £450m has been made of the cost of works needed at the seriously congested Underground stations (see Section 2.4). This figure assumes that some new sections of line will be constructed relieving certain stations as a result.

4.1.2 Investment to secure better operating performance

On both LUL and NSE, the number of trains actually operated during peak periods is less than the schedule. Congestion itself is an important cause of LUL's shortfall – extended station stops mean that it is neither possible to schedule the maximum number of trains nor to operate in full the scheduled service when it is most needed. This problem will get worse as congestion grows.

The Major Upgrading Programme would include expenditure of some £50m on a range of measures to improve operational performance: for example, measures to improve the operation of critical junctions and more rigid enforcement of station stop times.

New Network SouthEast Class 321 train designed to carry more passengers.

Tower Hill Underground station. Extended in 1988 to relieve congestion.

4.1.3 More Trains

Where the number of trains operated is below the maximum that a line can cater for, more passengers can be carried by investing in more trains and drivers. This is being programmed already on certain Network SouthEast lines, such as Moorgate-Bedford. On the Underground, 16 new trains are currently being brought into use to increase services on several lines. In general it has been assumed that a Major Upgrading Programme would increase service frequencies wherever this seems likely to be cost-effective.

A constraint on some lines is that the signalling system was not designed for maximum capacity because demand at the time did not justify it. Resignalling schemes are already programmed on sections of both Network SouthEast (services out of Marylebone) and the Underground (Central Line), to increase capacity. It has been assumed the Bakerloo and Jubilee lines would also be resignalled which together with infrastructure improvements and new trains would enable peak services to be increased.

4.1.4 Higher capacity trains

Where there is no room for more trains to run, it is sometimes possible to run longer trains. Platforms at all stations involved must then be lengthened. On a surface railway such as Network SouthEast this could be cost-effective. On the South-Eastern suburban lines from Charing Cross/Cannon Street to Dartford, Orpington and Hayes, longer platforms are already planned to serve 12-car trains. The case for similar extensions will be assessed on the routes to Cambridge once 12-car platforms can be provided at the London termini following the King's Cross and Liverpool Street developments.

There is, however, little scope for running longer trains on the Underground as the cost of lengthening deep level platforms and the disruption this would cause would generally be prohibitive.

New carriages can be designed to carry more passengers, for example by installing higher density seating to increase line capacity. This solution is proposed for some lines to Kent and Essex.

4.1.5 Service Restructuring

In some locations, the structure of services restricts the capacity that can be provided. A notable example is the Underground's Northern Line, where the junction at Kennington effectively imposes a limit of 24 trains per hour on the West End and City branches. If the Northern Line were operated as two separate lines, the frequency and reliability of the service on each could be enhanced. The Major Upgrading Programme contains a provision of some £60m for a package of improvements of this kind.

4.2

Such a Major Upgrading Programme would involve substantial expenditure. Preliminary estimates are as the table on the right shows:

4.3

The components of such a programme will be refined over the coming months with a view to ensuring that when projects come forward for full investment appraisal in due course they are likely to satisfy the criteria normally applied to such schemes by the railway operators and the Government. There may well be changes as a result, but the preliminary assessment which has been carried out is sufficiently encouraging to suggest that a programme of this type is a reasonable starting point for the assessment of more radical proposals. Such a programme would represent the maximum which could be done without new infrastructure. It would make the best use of existing assets in accordance with the Study's terms of reference.

4.4 Effects of a Major Upgrading Programme

The Major Upgrading Programme would produce a significant improvement compared with the very high levels of congestion which would otherwise be reached. It would not eliminate overcrowding on London's railways – though it should mean that conditions should not deteriorate too much over the coming years if growth does not exceed the Study's lower projections. The areas of congestion which are expected to remain in 2001 are illustrated in Figure 3 (page 10).

4.5 NSE

On most of Network SouthEast, the predicted traffic levels in 2001 could be accommodated by the provision of the additional coaches or complete trains envisaged in the Major Upgrading Programme. However, the critical sections from Liverpool Street to Shenfield and from Waterloo to Surbiton will continue to be overloaded even at the lower employment projection.

4.6 The Underground

On the Underground, Figure 3 (page 10) demonstrates that peak congestion is likely to remain widespread.

Summarising by line, the forecast position in 2001 after a Major Upgrading Programme would be as follows:

4.6.1 Bakerloo and Jubilee Lines

No overloading (peak train frequencies increased substantially by Major Upgrading Programme)

4.6.2 Central Line (after modernisation has increased peak capacity by 16 per cent)

Overcrowding reduced between Stratford and Liverpool Street as a result of competition from Docklands for office workers, but overloading still 25% despite increased peak frequencies.

Overcrowding increased compared with the present day between Liverpool Street and Chancery Lane, to 45% above planning standard. As today, this would remain the most heavily used section of the Underground.

4.6.3 District Line

Overcrowding increased between Parsons Green (Wimbledon Branch) and St James's Park: maximum overload 20% approaching Earl's Court from the south.

4.6.4 Metropolitan & Circle Lines

Slightly overloaded between Baker Street and Great Portland Street and between King's Cross and Farringdon (before allowing for any effects of the major development plans for King's Cross which still have to be fully evaluated).

Preliminary estimates for Major Upgrading Programme

	£ million
Relief of Underground station congestion	450
Improved Underground operating performance	50
Additional NSE rolling stock and platform extensions	600
Enhanced Underground services	400
Total	1500

4.6.5 Northern Line

Overcrowding in the central area eliminated by the restructuring envisaged in the Major Upgrading Programme.

Clapham Common to Stockwell 25% overloaded. (The southern part of the Northern Line cannot be increased in frequency.)

4.6.6 Piccadilly Line

Overloading expected to increase to 20% between Earl's Court and Knightsbridge.

4.6.7 Victoria Line

Increased overcrowding southbound between Euston and Oxford Circus, to a level of 25% above the planning standard. Northbound, overloading confined to the stretch between Victoria and Green Park.

Recently modernised platform at Embankment Underground station.

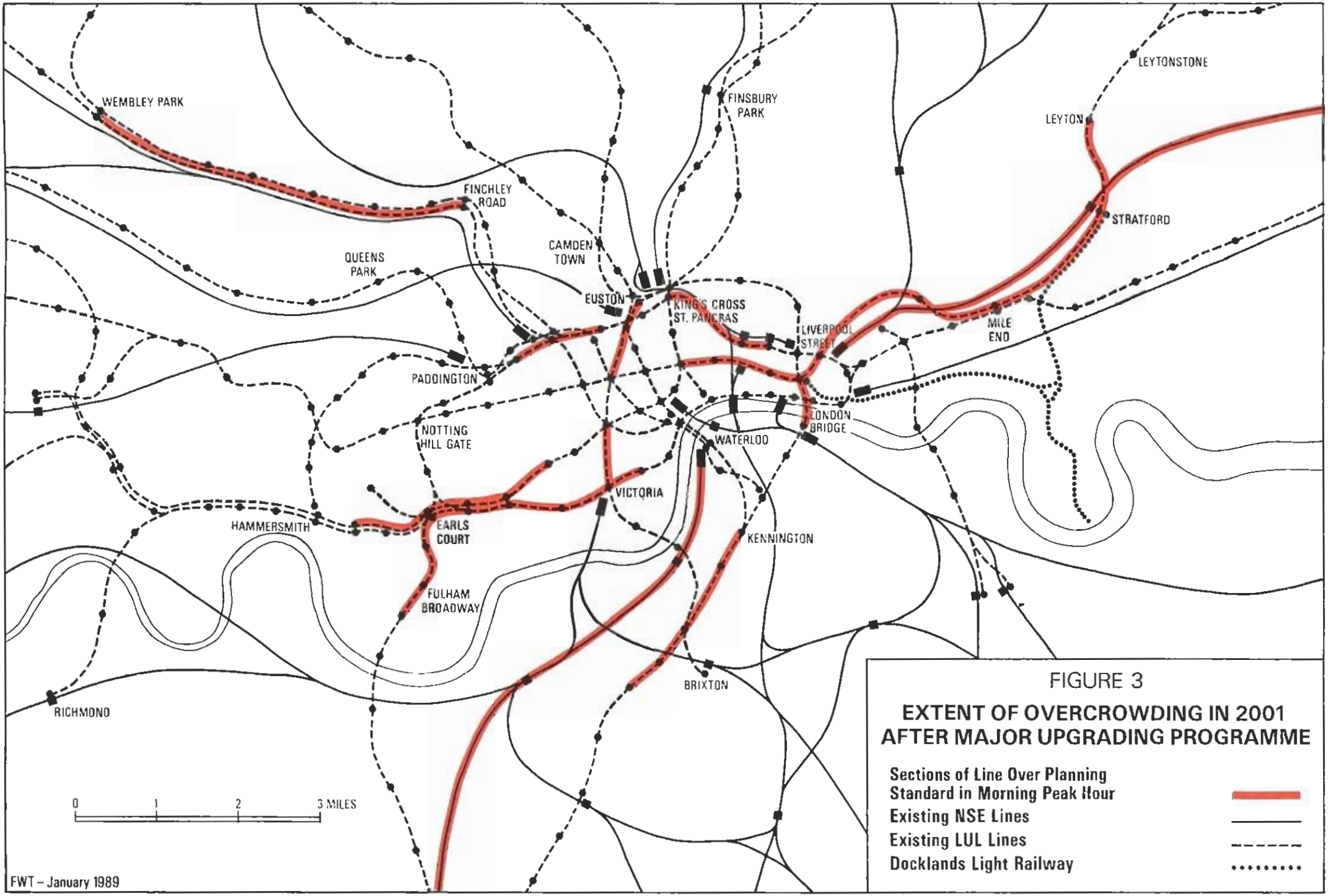


FIGURE 3

EXTENT OF OVERCROWDING IN 2001 AFTER MAJOR UPGRADING PROGRAMME

- Sections of Line Over Planning Standard in Morning Peak Hour
- Existing NSE Lines
- Existing LUL Lines
- Docklands Light Railway

5.0 NEW LINES AND EXTENSIONS

5.1 Introduction

Over the years, very many proposals have been put forward to improve London's rail system. These provide a wealth of ideas for tackling the congestion problems which are forecast to remain after a Major Upgrading Programme.

The proposals examined by the Study team fall into two categories:

- New Underground lines and extensions; and,
- Extension of surface lines to run under the central area – the "Crossrail" concept.

5.2 New Underground lines and extensions

Several options were examined by the Study team:

5.2.1 The overlapping Victoria Line Scheme

This scheme envisages a new tube line between King's Cross and Victoria creating two separate lines from the existing Victoria Line:
Line A: Brixton to King's Cross via existing route
Line B: Victoria to Walthamstow via new route to King's Cross, then by existing Victoria Line to Walthamstow, illustrated in Map 1.

Preliminary work indicates that such a scheme is feasible, though there would be major difficulties at King's Cross including diverting the existing Victoria Line whilst in full passenger use. A new depot site would also have to be found in the Brixton area or beyond.

Analysis of the traffic potential of the scheme indicates significant relief to the Victoria Line's central sections but little effect elsewhere. As a result of the additional interchanges required of many passengers at King's Cross and Victoria, the benefits of the scheme would be low relative to its cost (some £350m).

5.2.2 Jubilee Line Extension to Liverpool Street and Whitechapel

Jubilee Line trains from the north currently terminate at Charing Cross. An eastward extension to the City, aiming to relieve overcrowding on the Central Line, is an obvious possibility. From Charing Cross, the new line would run via Aldwych, Ludgate/Blackfriars to St Paul's, Liverpool Street and Whitechapel (see Map 2).

Feasibility of the scheme has been broadly established though the pace of development of buildings with deep foundations in the City is such that unless a route is safeguarded soon, it may not be possible to construct except at very deep level.

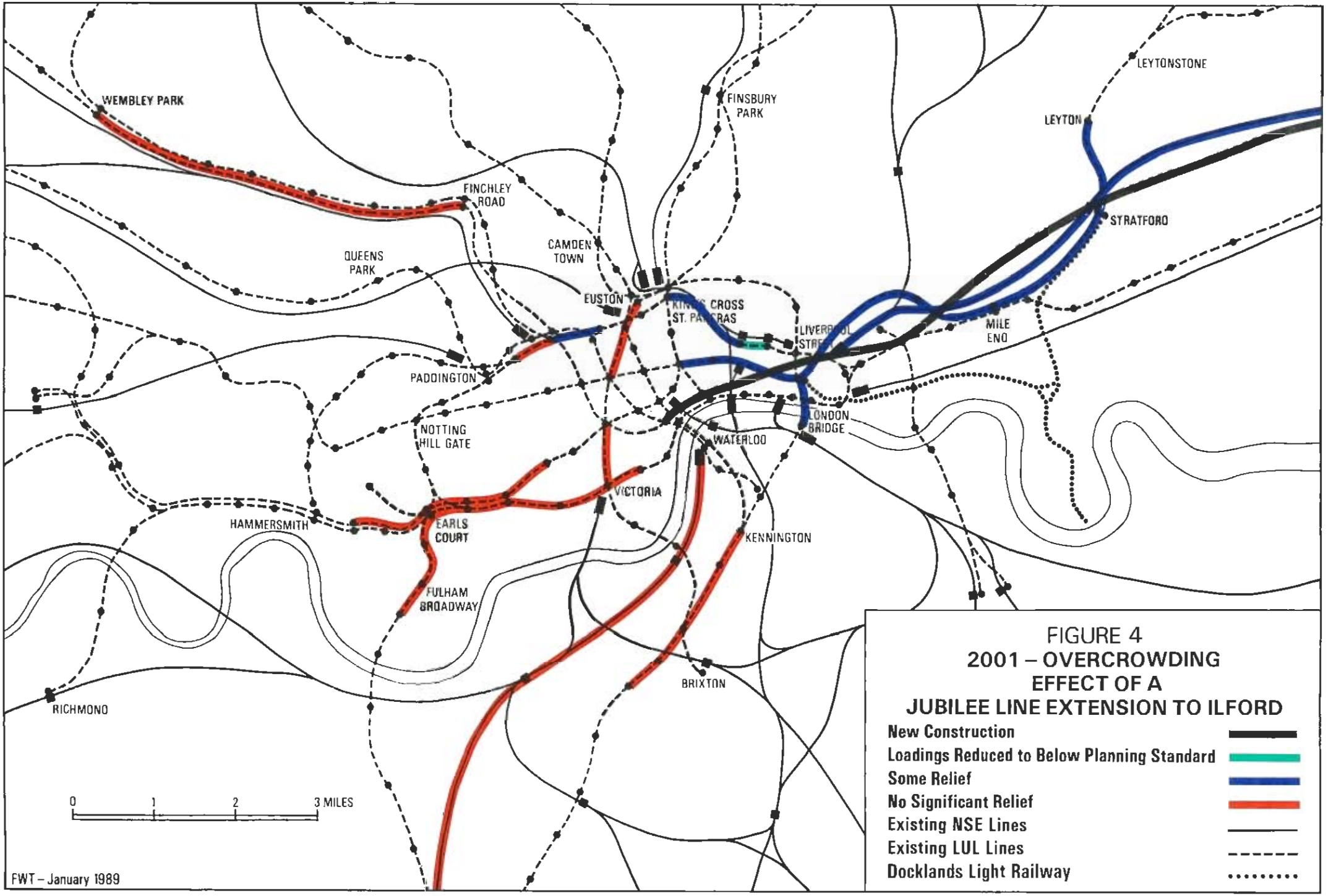
The traffic levels forecast for the scheme were relatively low, although significant relief of the Central Line was predicted. Again, the need to interchange appeared to be a major factor deterring use, and held benefits down well below the estimated cost.

5.2.3 Jubilee Line Extension to Ilford

Since the Central Line is overloaded for much of its length in East London, a further Jubilee Line extension to Stratford and Ilford was evaluated. This gives easy interchange with the District and East London Lines (see Map 2). Outline capital cost of the complete extension from Charing Cross is put at some £640m.

Analysis indicated that the most heavily loaded section of the new line would be between Whitechapel and Liverpool Street. However, the predicted peak hour load was only about half the capacity of the line. The only sections of the Underground where overcrowding would be relieved would be the Central Line and the Metropolitan/ Circle Lines, and on the most critical sections, relief would only be partial (see Figure 4, page 12). This reflects the fact that even in this form, access to the extended Jubilee Line would be limited and train speeds less than those of the BR network.

Extending the Jubilee Line to Ilford would, however, transfer a significant number of passengers from certain British Rail stations, allowing a reduction in the number of inner suburban trains. This, in turn, could allow some additional outer suburban trains to be operated, reducing overcrowding from towns such as Chelmsford. Overall, however, the case for this scheme seems much weaker than for other schemes to relieve the Central Line corridor.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STRATFORD
EUSTON
KINGS CROSS ST. PANCRAS
LIVERPOOL STREET
MILE END
PADDINGTON
NOTTING HILL GATE
LONDON BRIDGE
WATERLOO
VICTORIA
HAMMERSMITH
EARLS COURT
KENNINGTON
FULHAM BROADWAY
BRIXTON
RICHMOND
0 1 2 3 MILES
FWT – January 1989
FIGURE 4
2001 – OVERCROWDING
EFFECT OF A
JUBILEE LINE EXTENSION TO ILFORD
New Construction
Loadings Reduced to Below Planning Standard
Some Relief
No Significant Relief
Existing NSE Lines
Existing LUL Lines
Docklands Light Railway

5.2.4 Extension of the Jubilee Line to Docklands

Instead of a routeing via Liverpool Street, an extension of the Jubilee Line via London Bridge is a possibility (see Map 2). Preliminary work indicates that such a scheme on its own would have only a limited impact on central area congestion. However, from London Bridge it would be possible to extend the line further into Docklands, serving the Canary Wharf development on the Isle of Dogs. This would be an alternative to the stand-alone line being proposed by the Canary Wharf developers (see Map 4). Further evaluation of both these options is being carried out in the East London Rail Study.

Wall tiling at Green Park Underground station.

5.2.5 Chelsea-Hackney Line

A new tube line crossing London from south-west to north-east has been mooted for many years, and a number of different options are possible. A route via Victoria, King's Cross and Angel was chosen by the Study team for its main analysis, (See Map 3.) In the central area, the line would perform a similar function to the overlapping Victoria Line, but in addition would relieve the western part of the District Line, as well as giving a rail service for the first time to Chelsea and parts of Hackney. By linking into the Hainault branch of the Central Line, relief would also be given to the Central Line from Leytonstone to Holborn.

Feasibility of the scheme is not yet fully proven. Particular attention will need to be given to feasibility at Victoria and King's Cross and to the provision of a large surface site for a new depot. Outline capital cost is put at some £1330m.

Analysis of the scheme's traffic potential (see Figure 5, page 14) indicates that the alignment via King's Cross would carry substantial numbers of peak hour passengers from both east and west, up to 16,000 per hour (ie about 80% of the line's planning standard capacity) between Victoria and Piccadilly Circus. At the same time, substantial relief would be afforded on the District and Piccadilly Lines around Earl's Court and to the Victoria Line.

In addition, the Central Line would be relieved to some extent between Leytonstone and the City, with loadings reduced by up to 5,000 passengers per hour (reducing the excess demand above the planning standard from 45% to 30%). This would still leave some considerable overcrowding between Bethnal Green and the City as far as Chancery Lane.

The line would serve the Hackney, Dalston and Chelsea areas which are at present mainly dependent on buses for most public transport journeys. Substantial numbers of passengers would have considerable time savings. Despite its high cost, the scale of benefits produced suggests that the line might be worthwhile. Further detailed analysis is justified.

5.2.6 Southern Extension of the Bakerloo Line

The Bakerloo Line currently terminates at Elephant & Castle. It could be extended southwards, for example through the Old Kent Road area to New Cross Gate and Lewisham (see Map 4). This would increase accessibility in Inner London, but not increase capacity in the central area. Feasibility is broadly established.

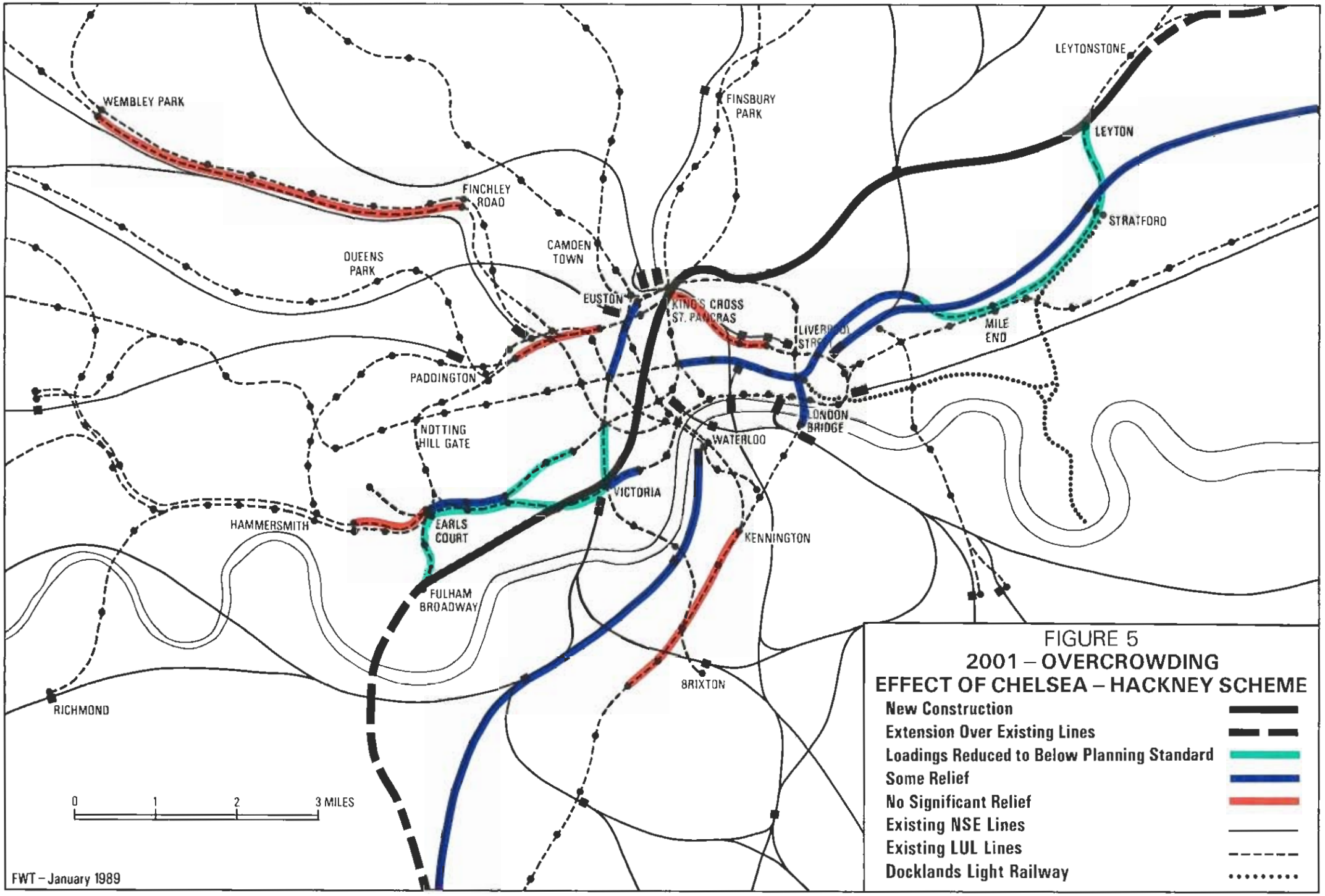
Traffic assessment indicates that the maximum load on the new section from Lewisham to Elephant & Castle would be 10,000 passengers per hour. There would be a transfer of about 4,000 passengers an hour from buses, and an equivalent number from Network SouthEast services through London Bridge.

The benefits appear to be encouraging compared with the costs, but, as it would not help to relieve congestion in the central area, it is not pursued further in this report.

5.2.7 The Western Package

This scheme envisages that a new section of the Central Line would be constructed from Shepherds Bush to Turnham Green. Richmond would then be served by the Central Line instead of the District and the frequency of District Line services to other western destinations increased. To avoid the complication of three Central Line branches, a further part of the package could be a new link from the Bakerloo Line at Queens Park to the Central Line at North Acton, and thence to Ealing Broadway (see Map 5).

Feasibility has been established and outline capital costs including the Bakerloo line branch would be some £150m.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STRATFORD
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PADDINGTON
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EARLS COURT
HAMMERSMITH
KENNINGTON
FULHAM BROADWAY
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FWT – January 1989
FIGURE 5
2001 – OVERCROWDING
EFFECT OF CHELSEA – HACKNEY SCHEME
New Construction
Extension Over Existing Lines
Loadings Reduced to Below Planning Standard
Some Relief
No Significant Relief
Existing NSE Lines
Existing LUL Lines
Docklands Light Railway

The two new sections of the line proposed in the western suburbs between North Acton and Queen's Park (Bakerloo) and between Turnham Green and Shepherd's Bush (Central) would carry relatively small numbers of passengers (3000-4000 in the peak hour). Nevertheless, this package would relieve both District and Piccadilly Lines in the Earl's Court area; indeed this is the only scheme which would reduce passenger loads on the Piccadilly Line below planning standard.

The scheme has a number of promising aspects but further work is needed before a definite view of its potential can be reached.

5.3 Crossrail

The Crossrail concept is substantially different from all the previous schemes in proposing BR-gauge tunnels under central London to link existing rail services on either side. This would allow many suburban areas to be linked direct to central London destinations for the first time. Crossrail would relieve congestion at the main-line terminals and on some of the most crowded sections of the Underground and enable better use to be made of certain suburban rail corridors. It would also release valuable capacity at BR terminals, which could be used for longer distance commuter trains.

Four major Crossrail routes were considered in the Study.

5.3.1 North-South Crossrail

From Euston/King's Cross to Victoria, with intermediate stations at Tottenham Court Road and Piccadilly Circus (Map 6).

5.3.2 East-West Crossrail

From Liverpool Street to Paddington/ Marylebone and the Metropolitan Line with intermediate stations at Farringdon, Tottenham Court Road and Bond Street (Map 6).

5.3.3 City Crossrail

From London Bridge to Essex Road with intermediate stations at Fenchurch Street and Liverpool Street (Map 6).

5.3.4 Thameslink Metro

Unlike the above schemes this is not a new line but an enhancement of an existing one. The Major Upgrading Programme allows for 8 trains in the peak hour in each direction through Thameslink between King's Cross and Blackfriars – a considerable increase on the current service. The Thameslink Metro scheme would develop Thameslink services still further to provide a concentrated, high frequency service similar to that provided by, for example, the District Line (Map 7).

Feasibility of the Crossrail schemes has been broadly established, although finding suitable routes, station locations and working sites will become more difficult as time goes by. Outline capital costs (including rolling stock) are as follows:

- North-South Crossrail £895m
- East-West Crossrail £885m
- City Crossrail £520m
- Thameslink Metro £330m

The North-South and East-West schemes can be considered as a single package (the "Full Cross"). Alternatively, only some arms of the Full Cross could be constructed to give, for example, an East-South scheme from Victoria to Liverpool Street via Tottenham Court Road and Farringdon.

5.4

Results of initial traffic analyses of the schemes are as follows:

5.4.1 North-South Crossrail

The southern section, from Victoria to Piccadilly Circus, would carry over 20,000 passengers in the peak hour, the highest load on any of the new lines tested. The northern section, from King's Cross to Tottenham Court Road, would be much more lightly loaded, with 8000 passengers in the peak hour. The scheme would provide relief for the Northern and Victoria Lines.

5.4.2 East-West Crossrail

Of all the schemes tested, this is the one which comes closest to eliminating overcrowding on the most heavily loaded section of the Underground between Liverpool Street and Chancery Lane. It is also the only one to reduce loads to below planning standard on the Metropolitan/Circle line east of Baker Street. It has some effect on the District and Piccadilly Lines around Earl's Court; this is because many passengers from the Ealing area would use Crossrail in preference to the Underground.

5.4.3 City Crossrail

The scheme would do little to relieve overcrowding but direct passenger benefits and loadings (10,000 from the north and 16,000 from the south in the peak hour) would be quite high.

5.4.4 Thameslink Metro

The capacity of Thameslink is at present limited by its signalling system on some sections, and most of the suburban lines have capacity constraints at junctions. To run a more intensive service would require significant expenditure on flyovers, trackwork and signalling, as well as new trains, but still far less than on a brand-new line.

To assess the potential value of an intensive Thameslink service a scheme with 10 trains per hour from St Alban's to Wimbledon and Sutton, and 10 trains per hour from Enfield Chase to Croydon was tested, with new stations at Camberwell, Walworth and Southwark.

Results showed a high level of use with 18,000 passengers in the peak hour on the cross central London link. Some relief was provided to the Underground (see Figure 6, page 18) notably to the overcrowded section of the Northern Line through Clapham.

5.5 Short-listing of projects

Of the schemes tested, the least cost-effective appeared to be those which provided new Underground capacity only within the central area, i.e. the overlapping Victoria Line scheme and the Jubilee Line extension to Liverpool Street and Whitechapel. It is proposed to discard these proposals at this stage.

Three of the proposals for new Underground lines do not appear to contribute significantly to solving the central area congestion problem, and have been set aside for the purposes of the present report. They are:

- the southern extension of the Bakerloo Line
- the extension of the Jubilee Line to Docklands
- the "Western Package".

However, further work on these schemes is planned. A review of the Jubilee Line–Docklands option, in particular, is being given a high priority, within the context of the East London Rail Study.

The City Crossrail option has also been put to one side as it would similarly do little to solve the central area congestion problem.

The remaining sections of this report look more closely at the case for the other schemes described in this section.

6.0 EVALUATION OF SCHEMES

6.1 Introduction

This section of the report presents preliminary estimates of the costs and benefits of schemes or combinations of schemes which seem promising in the light of the analysis in Section 5 and which would help to relieve the congestion which is forecast to remain after a Major Upgrading Programme.

These are:

- Chelsea-Hackney Line
- a Jubilee Line extension from Charing Cross to Ilford
- Thameslink Metro
- East-South Crossrail (linking Victoria and Liverpool Street)
- East-West and North-South Crossrail (individually and in combination as the "Full Cross" scheme)
- a package consisting of East-West Crossrail plus the Chelsea-Hackney line.

6.2 Costs

Broad cost estimates are given in Table 1. The differences between the schemes are largely determined by the length and diameter of tunnels (3.85m for Underground trains or 5.9m for BR stock), the ground conditions likely to be encountered and the number and complexity of stations.

The rolling stock cost depends on the number of trains required for the peak service frequencies envisaged. In the case of Crossrail it is assumed that few additional trains would be needed because through running would allow better use to be made of the existing number of trains. In contrast the Chelsea-Hackney Line would require some 80 new trains, a fully equipped main depot and considerable stabling.

6.3 Benefits

Estimated passenger benefits of the scheme at the lower demand growth assumption are set out in Table 2. The benefits assessed for each scheme include time saving to existing users, reduced congestion on trains and in stations, revenues from generated travel, relief of road congestion and reduction in road accidents.

Except for the Jubilee Line extension to Ilford, a major source of benefit is time saved by public transport passengers. The Jubilee Line extension suffers in this respect because it offers few new or faster links.

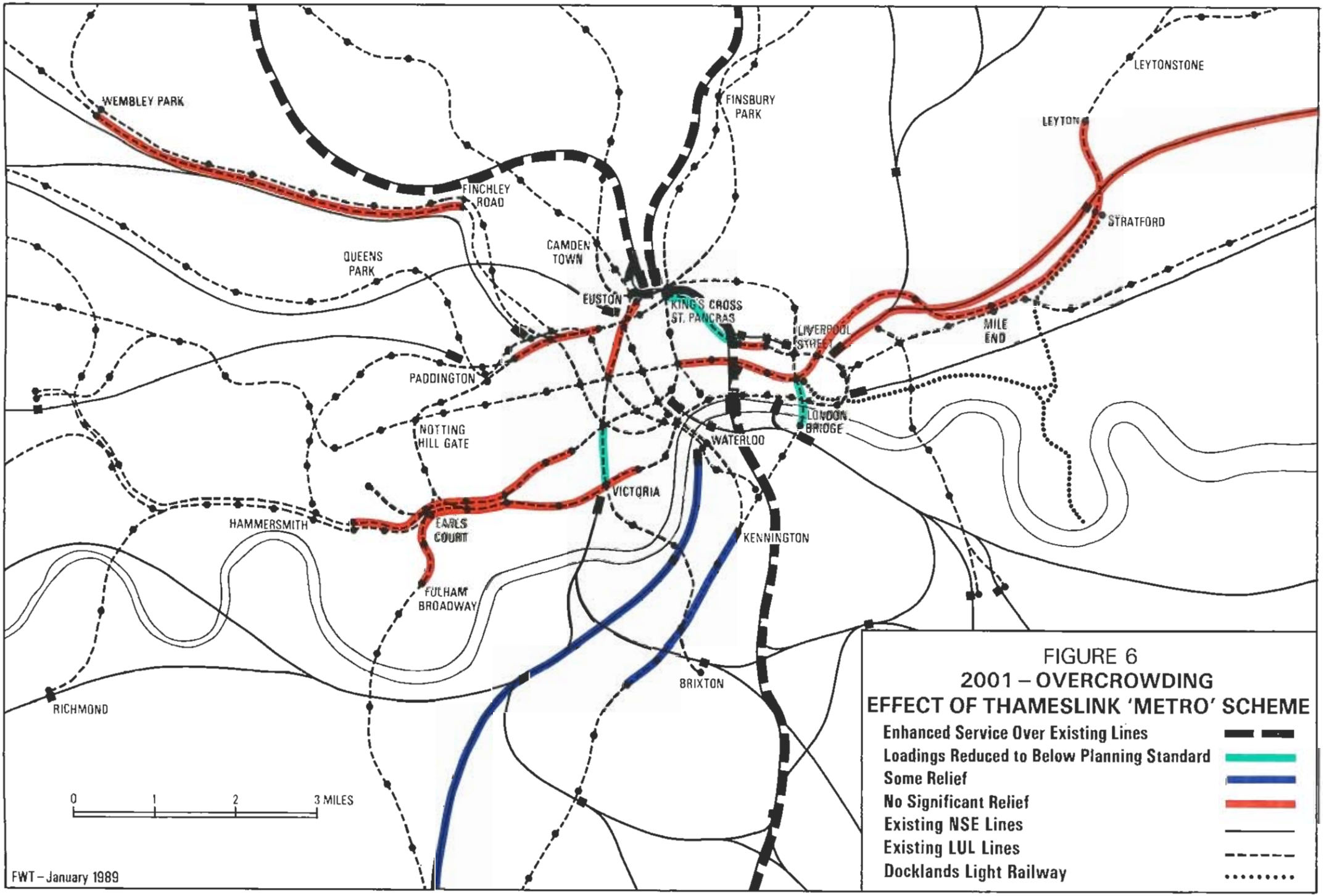
TABLE 1: COSTS OF NEW RAIL SCHEMES (£m) 1988 prices

Single Line Schemes	Capital Cost of Construction	Rolling Stock Costs	Equivalent Annual Capital Cost	Annual Operating Cost	Total Equivalent Annual Cost
Chelsea-Hackney	1000	330	110	40	150
Jubilee Line Extension to Ilford	560	80	55	15	70
Thameslink Metro	260	70	25	25	50
East-West Crossrail	870	15	75	10	85
North-South Crossrail	840	55	75	10	85
East-South Crossrail	650	50	60	10	70
Two Line Packages					
Full Cross	1710	70	150	20	170
East-West Crossrail plus Chelsea-Hackney	1870	345	185	50	235

Notes
1. Capital cost discounted at 7% per annum over 60 years (35 years for trains)
2. Construction cost spread over a five year period prior to line opening.

TABLE 2: ESTIMATED BENEFITS OF NEW RAIL SCHEMES (£m p.a.) 1988 prices

Single Line Schemes	Time Savings	Crowding Relief	Total Public Transport Users' Benefit	Road Users' Benefit	Additional Rail Revenue	Total Benefit
Chelsea-Hackney	60	30	90	20	20	130
Jubilee Line Extension to Ilford	5	25	30	5	5	40
Thameslink Metro	55	20	75	15	15	105
East-West Crossrail	30	70	100	20	20	140
North-South Crossrail	40	15	55	10	10	75
East-South Crossrail	55	40	95	20	20	135
Two Line Packages						
Full Cross	70	85	155	30	30	215
East-West Crossrail plus Chelsea-Hackney	90	100	190	40	40	270


WEMBLEY PARK
FINSBURY PARK
LEYTONSTONE
LEYTON
FINCHLEY ROAD
STRATFORD
QUEENS PARK
CAMDEN TOWN
EUSTON
KING'S CROSS ST. PANCRAS
LIVERPOOL STREET
MILE END
PADDINGTON
LONDON BRIDGE
NOTTING HILL GATE
WATERLOO
VICTORIA
HAMMERSMITH
EARLS COURT
KENNINGTON
FULHAM BROADWAY
BRIXTON
RICHMOND
0 1 2 3 MILES
FWT – January 1989
FIGURE 6
2001 – OVERCROWDING
EFFECT OF THAMESLINK 'METRO' SCHEME
Enhanced Service Over Existing Lines
Loadings Reduced to Below Planning Standard
Some Relief
No Significant Relief
Existing NSE Lines
Existing LUL Lines
Docklands Light Railway

By contrast, time savings provide the Chelsea-Hackney Line's principal source of benefit. This reflects the new areas served and the additional, more direct, links provided by the line. Congestion relief benefits are, however, still significant. Thameslink Metro's benefit profile is similar.

The Crossrail schemes score very highly in reducing overcrowding and road traffic congestion. East-West and East-South Crossrail, in particular, both produce very substantial overcrowding relief while also producing net time savings. North-South Crossrail's benefits, on the other hand, have a profile more akin to that of the Chelsea-Hackney Line.

6.4 Cost benefit assessment

Table 3 shows how the estimated costs of the scheme compare with the benefits to:

- public transport users
- road users
- the railway operators (additional revenue).

The Jubilee Line extension to Ilford is the only scheme for which costs significantly exceed benefits, its poor showing reflecting the low time saving benefits it offers. It would not have a major impact on central area congestion and it is therefore proposed to discard this option.

TABLE 3: ESTIMATED BENEFIT-COST RATIOS OF NEW RAIL SCHEMES BASED ON TABLES 1 AND 2

Benefits as a Proportion of Total Annual Cost	To Public Transport Users	To Road Users	Revenue Gain	Total
Single Line Schemes				
Chelsea-Hackney	0.6	0.1	0.1	0.9
Jubilee Line Extension to Ilford	0.4	0.1	0.1	0.6
Thameslink Metro	1.5	0.3	0.3	2.1
East-West Crossrail	1.2	0.2	0.2	1.6
North-South Crossrail	0.6	0.1	0.1	0.9
East-South Crossrail	1.4	0.3	0.3	1.9
Two Line Packages				
Full Cross	0.9	0.2	0.2	1.3
East-West Crossrail plus Chelsea-Hackney	0.8	0.2	0.2	1.1

Rows may not sum up due to rounding

The remaining schemes all have benefits which are estimated either to be approximately equal to costs or to exceed costs. All make significant inroads into the congestion problems but no single scheme would come near to providing a full solution. The Study has therefore considered packages based on two major new lines.

Of the schemes tested involving major new lines, the East-South and East-West Crossrail options have the highest benefit to cost ratios. The East-South option linking Liverpool Street and Victoria combines a short length of new tunnel with the relief of two key sections of overloaded line – the Central Line eastbound from Stratford and the Victoria Line northbound from Victoria. However, the scheme offers no relief to other areas of congestion and complementary schemes are difficult to design. The East-West option on the other hand could be combined with either a North-South Crossrail or the Chelsea-Hackney Line. Both of the two-line packages thus created would provide something close to a complete solution – see Figure 7 (page 20) and Figure 8 (page 21). As Table 3 indicates, both two line packages appear to have benefits which significantly exceed costs.

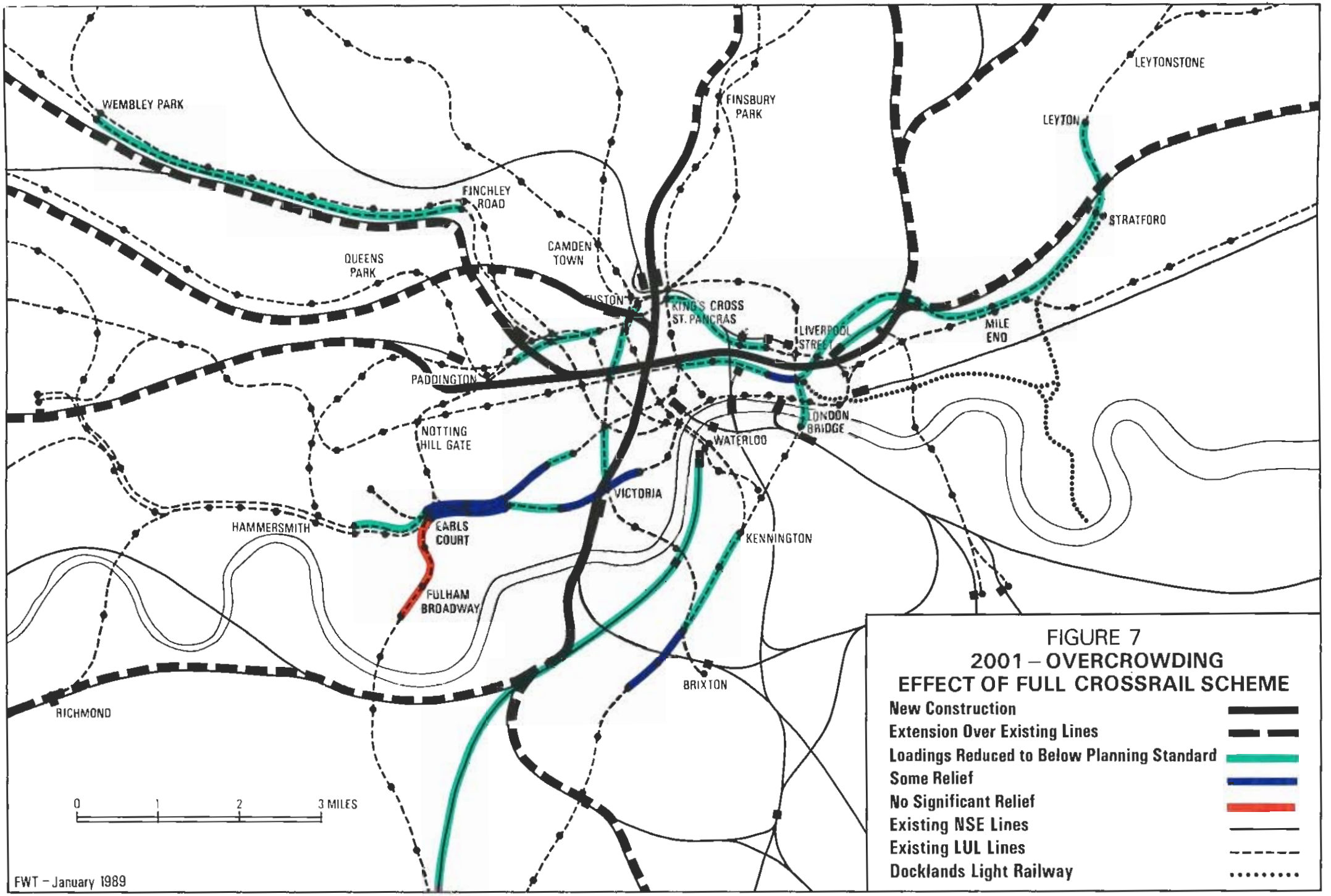
The Thameslink Metro has benefits which are over twice its costs. It is not, however, a new line and its impact on congestion is limited. It can be considered as a subsidiary option to add to one or other of the two-line packages identified. It would be physically feasible to combine it with both packages but it would compete to some extent with a North-South Crossrail, reducing the attractiveness of that option.

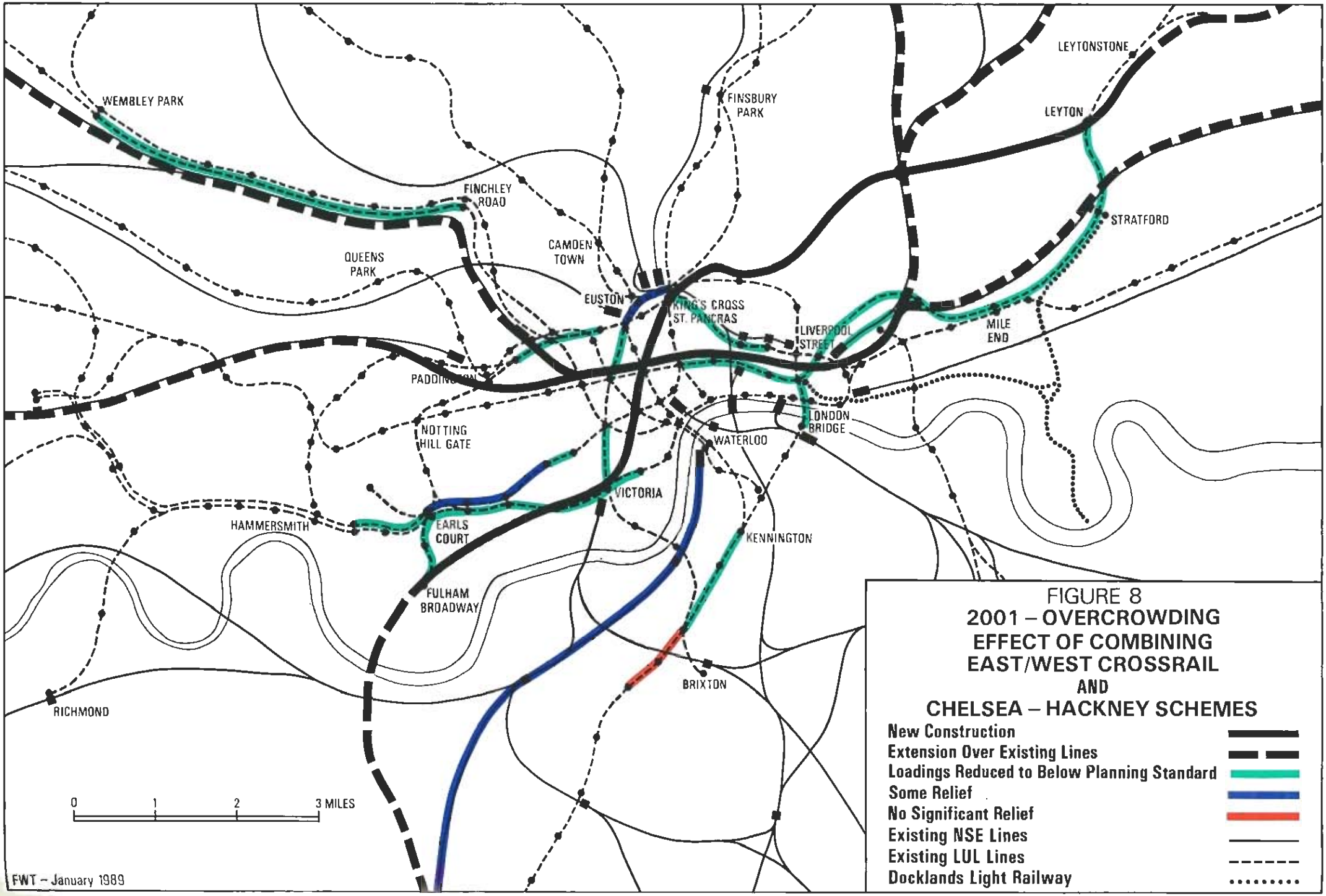
6.5

On the basis of this analysis it would appear that two new lines would need to be built to provide a full solution. The two most promising two-line options are:

- the Full Cross scheme and
- East-West Crossrail plus the Chelsea-Hackney Line.

Further detailed work, including a refinement of the physical specifications of the individual options, is needed to clarify the results of the cost/benefit analysis conducted so far.


WEMBLEY PARK
FINSBURY PARK
LEYTONSTONE
LEYTON
FINCHLEY ROAD
STRATFORD
CAMDEN TOWN
QUEENS PARK
KING'S CROSS ST. PANCRAS
LIVERPOOL STREET
MILE END
PADDINGTON
LONDON BRIDGE
NOTTING HILL GATE
WATERLOO
VICTORIA
HAMMERSMITH
EARLS COURT
KENNINGTON
FULHAM BROADWAY
BRIXTON
RICHMOND
0 1 2 3 MILES
FWT – January 1989
FIGURE 7
2001 – OVERCROWDING
EFFECT OF FULL CROSSRAIL SCHEME
New Construction
Extension Over Existing Lines
Loadings Reduced to Below Planning Standard
Some Relief
No Significant Relief
Existing NSE Lines
Existing LUL Lines
Docklands Light Railway


WEMBLEY PARK
FINSBURY PARK
LEYTONSTONE
LEYTON
FINCHLEY ROAD
STRATFORD
CAMDEN TOWN
QUEENS PARK
EUSTON
KING'S CROSS ST. PANCRAS
LIVERPOOL STREET
MILE END
PADDINGTON
NOTTING HILL GATE
LONDON BRIDGE
WATERLOO
VICTORIA
HAMMERSMITH
EARLS COURT
KENNINGTON
FULHAM BROADWAY
BRIXTON
RICHMOND
0 1 2 3 MILES
FIGURE 8
2001 – OVERCROWDING
EFFECT OF COMBINING
EAST/WEST CROSSRAIL
AND
CHELSEA – HACKNEY SCHEMES
New Construction
Extension Over Existing Lines
Loadings Reduced to Below Planning Standard
Some Relief
No Significant Relief
Existing NSE Lines
Existing LUL Lines
Docklands Light Railway
FWT – January 1989

6.6 Financial Appraisal

The Government's policy on the financing of rail services was set out in its observations on the House of Commons Transport Committee Third Report, Session 1986-87, and was published as Cm.420 on 30 March 1988. The Government expects to approve investment in railways, where the investment will earn a commercial return. Each scheme, or recommended package of schemes, has therefore to be tested against that standard and modifications made with a view to maximizing the revenues in relation to the costs. Account also needs to be taken of the effects of each scheme over the wider network. In principle, the schemes able to earn the best returns on the capital invested should also be those which best meet the needs of passengers as measured by their willingness to pay for them.

Some of the schemes under consideration, or parts of them, would also enhance land values or otherwise generate significant benefits for particular businesses or landowners. Such beneficiaries may wish to enter into negotiation with the railway operators with a view to influencing the choice of routes, or their alignments, or the siting of stations in return for a significant financial contribution to reflect the benefits they would derive. These possibilities would have to be explored case by case. Experience of the Docklands Light Railway and the Paddington/Heathrow Link show that the private sector is prepared to make substantial contributions towards the cost of improved transport links where they will result in development gain or other commercial benefits.

If the revenues which can be expected from fares, together with financial contributions from developers, are not sufficient to pay for a scheme, the Government will consider the case for a grant, if there are sufficient non-user benefits (eg in the relief of road congestion) to justify the amount requested to make the investment financially viable in accordance with the usual test discount rate.

6.7 Sensitivity Analysis

The results depend critically on the planning assumptions. Lower employment levels would deflate benefits roughly proportionately. If costs exceed the estimates, the case for the schemes would be similarly weakened. On the other hand, further employment growth would inflate benefits rather more than in proportion as crowding levels would become severe. On the whole, given the current trends in commuting revealed by the latest Peak Count Surveys, estimates of benefits may be cautious rather than optimistic.

These uncertainties will have to be taken into account in devising a strategy in which there should be as much scope as possible for varying both the content and timing of future investments in response to significant changes in the underlying forecasts and assumptions.

7.0 CONCLUSIONS

7.1

Today's record demand for peak passenger travel on the rail systems serving central London is likely to increase by up to 20% by the end of the century.

7.2

To meet this demand a Major Upgrading Programme, costing some £1.5bn. is proposed to make best use of the existing infrastructure. This would help to deal with overcrowding, but would not by itself be enough to cater for the forecast increases in demand and provide acceptable standards of quality for London's rail passengers in the longer term.

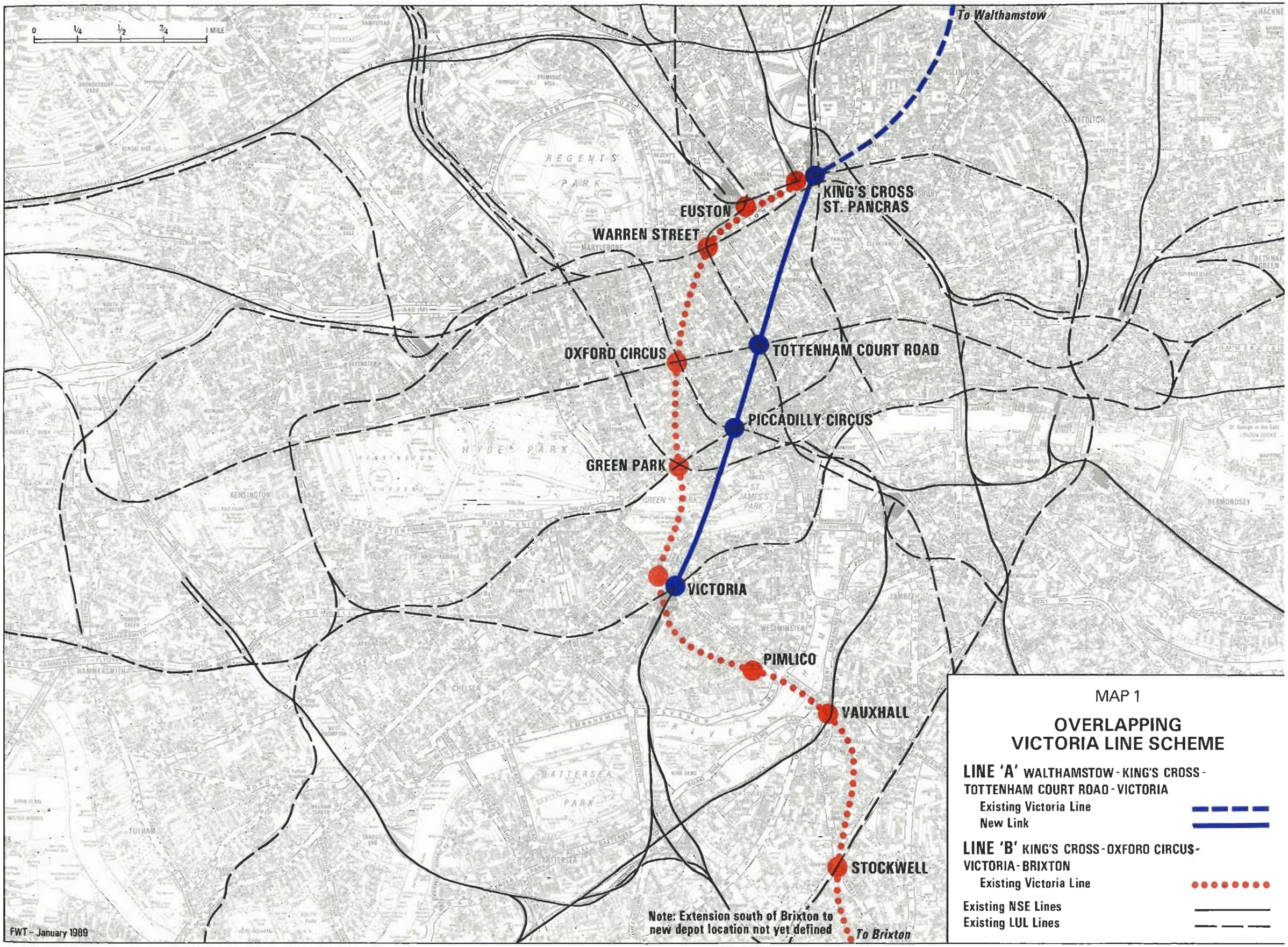
7.3

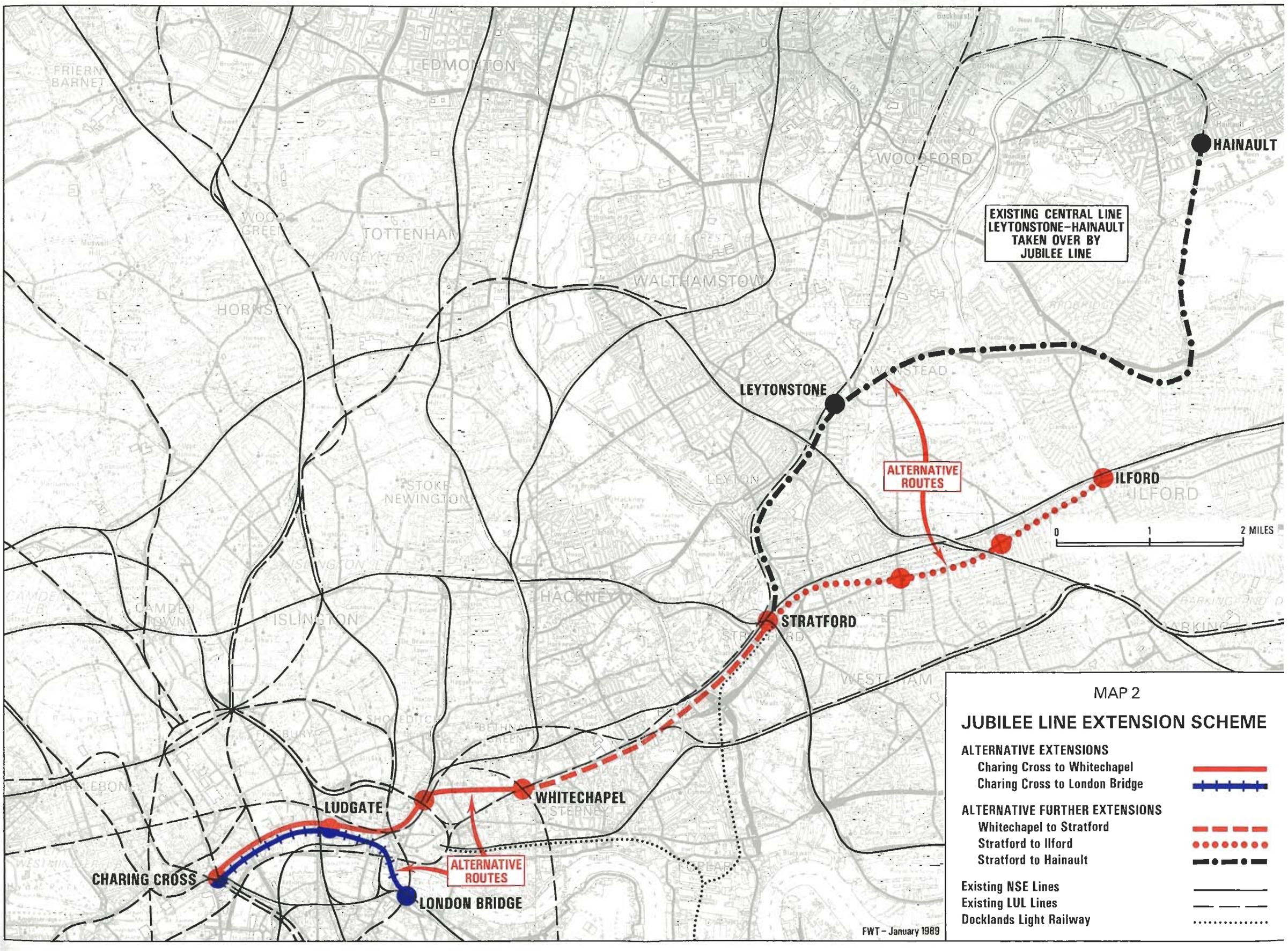
To resolve this further problem, two alternative major packages of investment have been identified as sufficiently promising to merit further development, involving new railway lines across London. One package, known as the "Full Cross", consists of BR-gauge tunnels joining Euston/Kings Cross in the north with Victoria in the south, and Liverpool Street in the east with Paddington and Marylebone in the west. The other package would involve the same east-west line ("East-West Crossrail") plus a new tube-gauge line joining Wimbledon to Hainault via Chelsea and Hackney (the "Chelsea-Hackney Line"). The capital cost of these options is of the order of £2bn. Further detailed work is needed on the refinement of the physical specification of these options before a clear choice can be made as a basis for decisions. This work will now be carried forward.

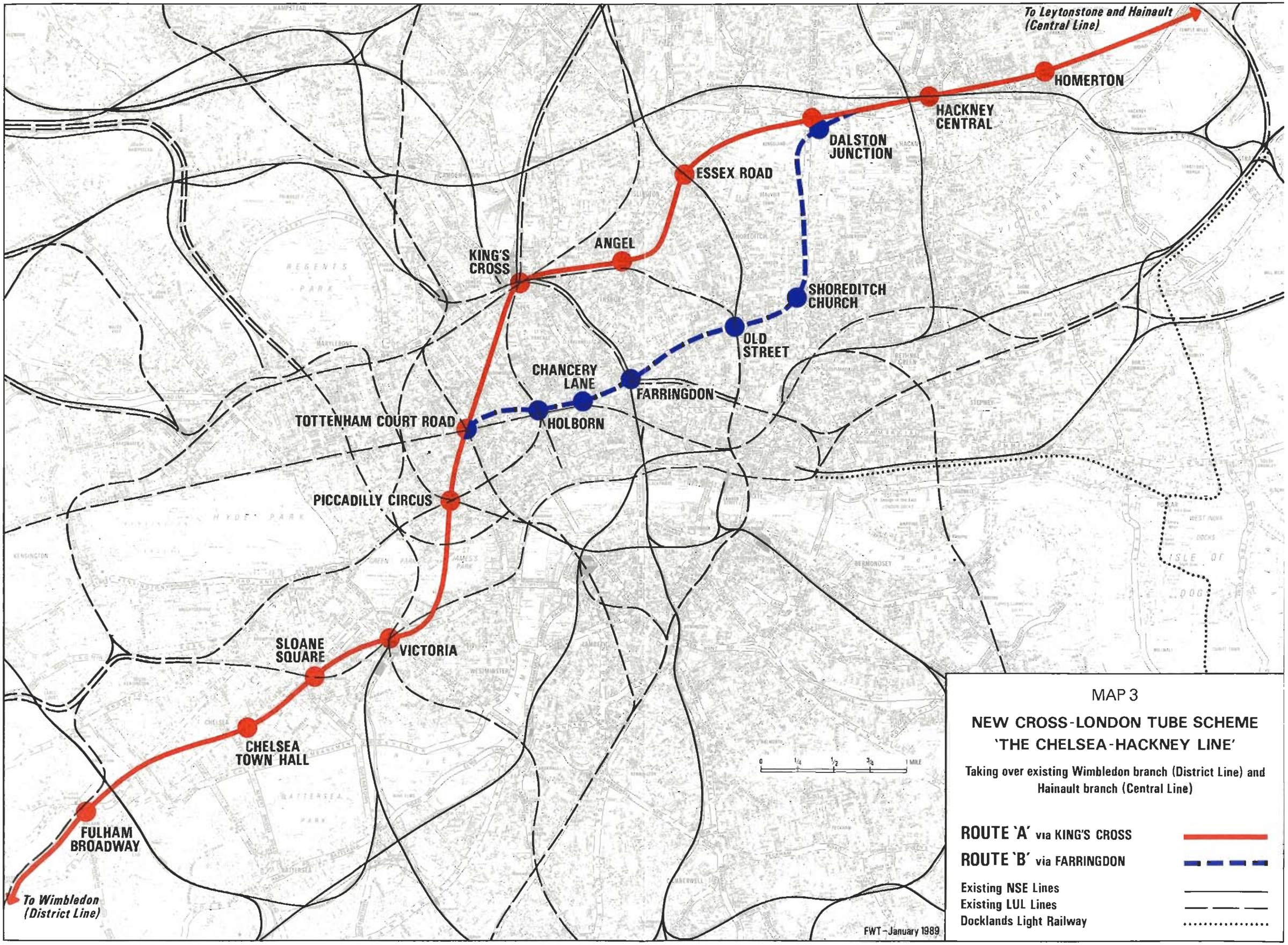
7.4

There is a need to demonstrate that the preferred schemes can be financially sound. This must be assessed in relation to the commercial objectives set for the two London rail operators, the implication for fares, and the case for any Government subsidy.

Thameslink train at Blackfriars.


0
1/4
1/2
3/4
1 MILE
To Walthamstow
KING'S CROSS
ST. PANCRAS
EUSTON
WARREN STREET
OXFORD CIRCUS
TOTTENHAM COURT ROAD
PICCADILLY CIRCUS
GREEN PARK
VICTORIA
PIMLICO
VAUXHALL
STOCKWELL
To Brixton
Note: Extension south of Brixton to new depot location not yet defined
REGENTS PARK
HYDE PARK
BATTERSEA PARK
ISLINGTON
SHOREDITCH
BERMONDSEY
KENSINGTON
CHELSEA
WESTMINSTER
HAMMERSMITH
FULHAM
LAMBETH
MAP 1
OVERLAPPING
VICTORIA LINE SCHEME
LINE 'A' WALTHAMSTOW - KING'S CROSS - TOTTENHAM COURT ROAD - VICTORIA
Existing Victoria Line
New Link
LINE 'B' KING'S CROSS - OXFORD CIRCUS - VICTORIA - BRIXTON
Existing Victoria Line
Existing NSE Lines
Existing LUL Lines
FWT - January 1989


EXISTING CENTRAL LINE
LEYTONSTONE–HAINAULT
TAKEN OVER BY
JUBILEE LINE
HAINAULT
LEYTONSTONE
ALTERNATIVE
ROUTES
ILFORD
0
1
2 MILES
STRATFORD
WHITECHAPEL
LUDGATE
CHARING CROSS
ALTERNATIVE
ROUTES
LONDON BRIDGE
FWT – January 1989
MAP 2
JUBILEE LINE EXTENSION SCHEME
ALTERNATIVE EXTENSIONS
Charing Cross to Whitechapel
Charing Cross to London Bridge
ALTERNATIVE FURTHER EXTENSIONS
Whitechapel to Stratford
Stratford to Ilford
Stratford to Hainault
Existing NSE Lines
Existing LUL Lines
Docklands Light Railway



MAP 3

NEW CROSS-LONDON TUBE SCHEME 'THE CHELSEA-HACKNEY LINE'

Taking over existing Wimbledon branch (District Line) and Hainault branch (Central Line)

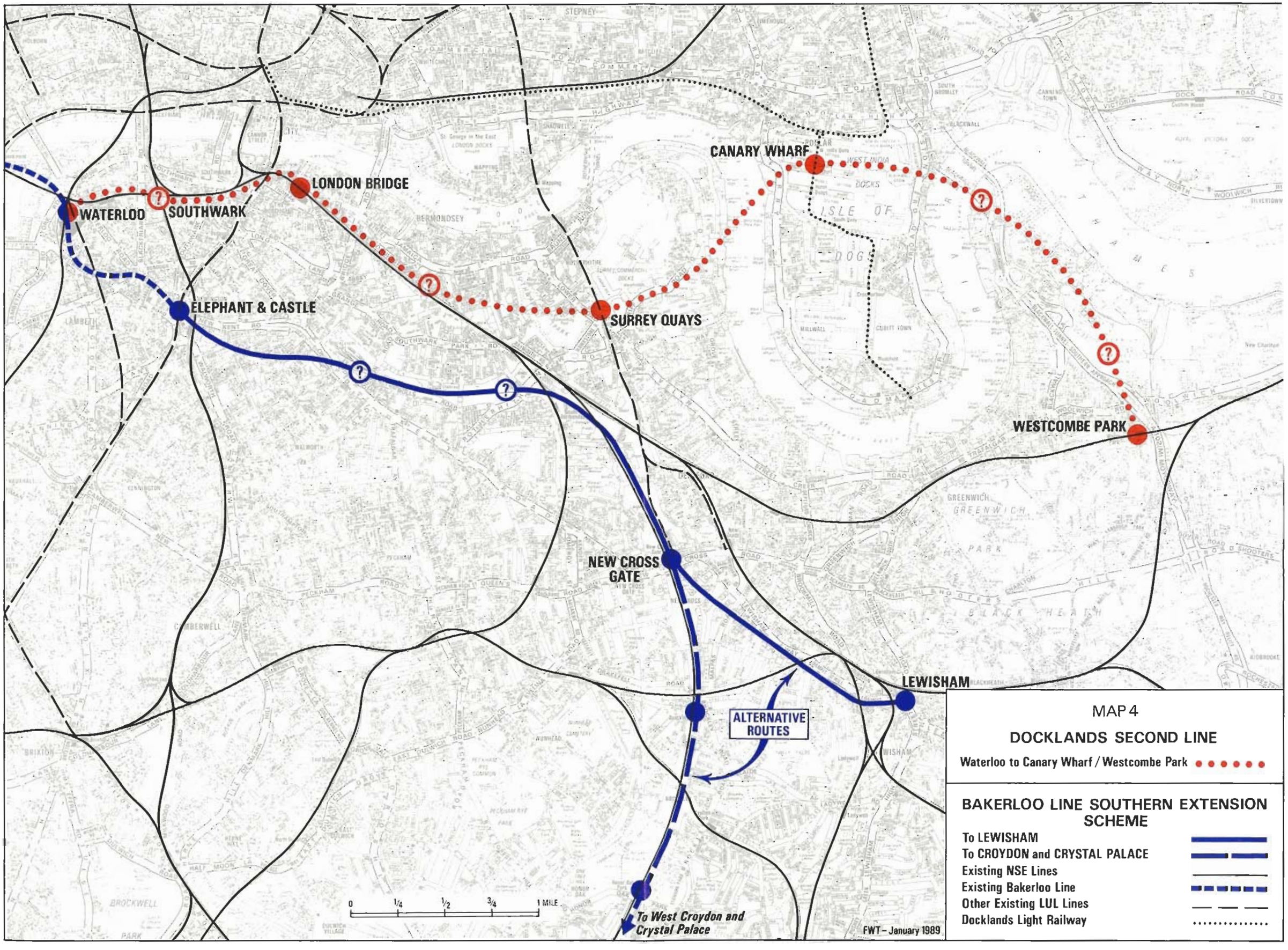
ROUTE 'A' via KING'S CROSS

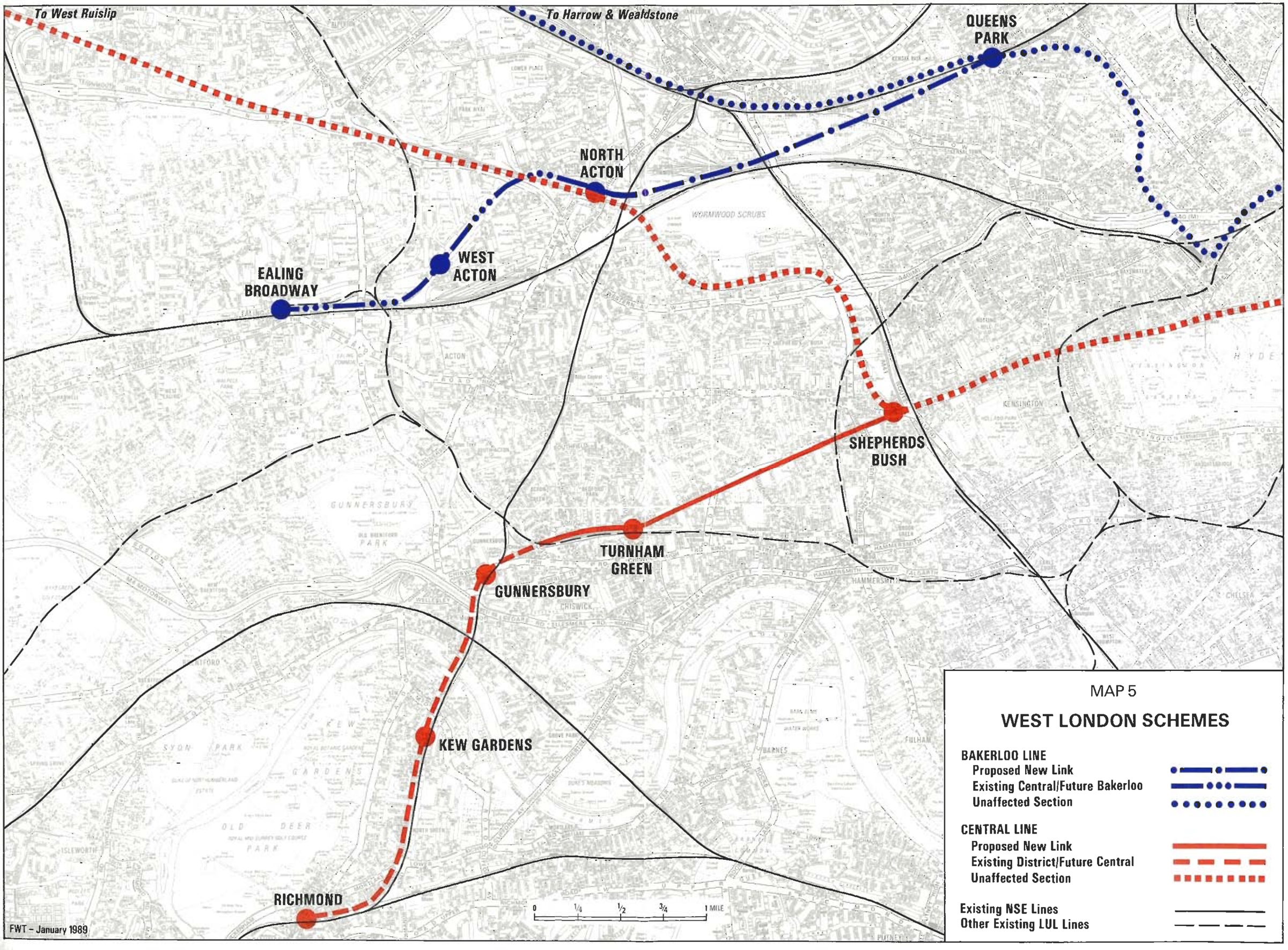
ROUTE 'B' via FARRINGDON

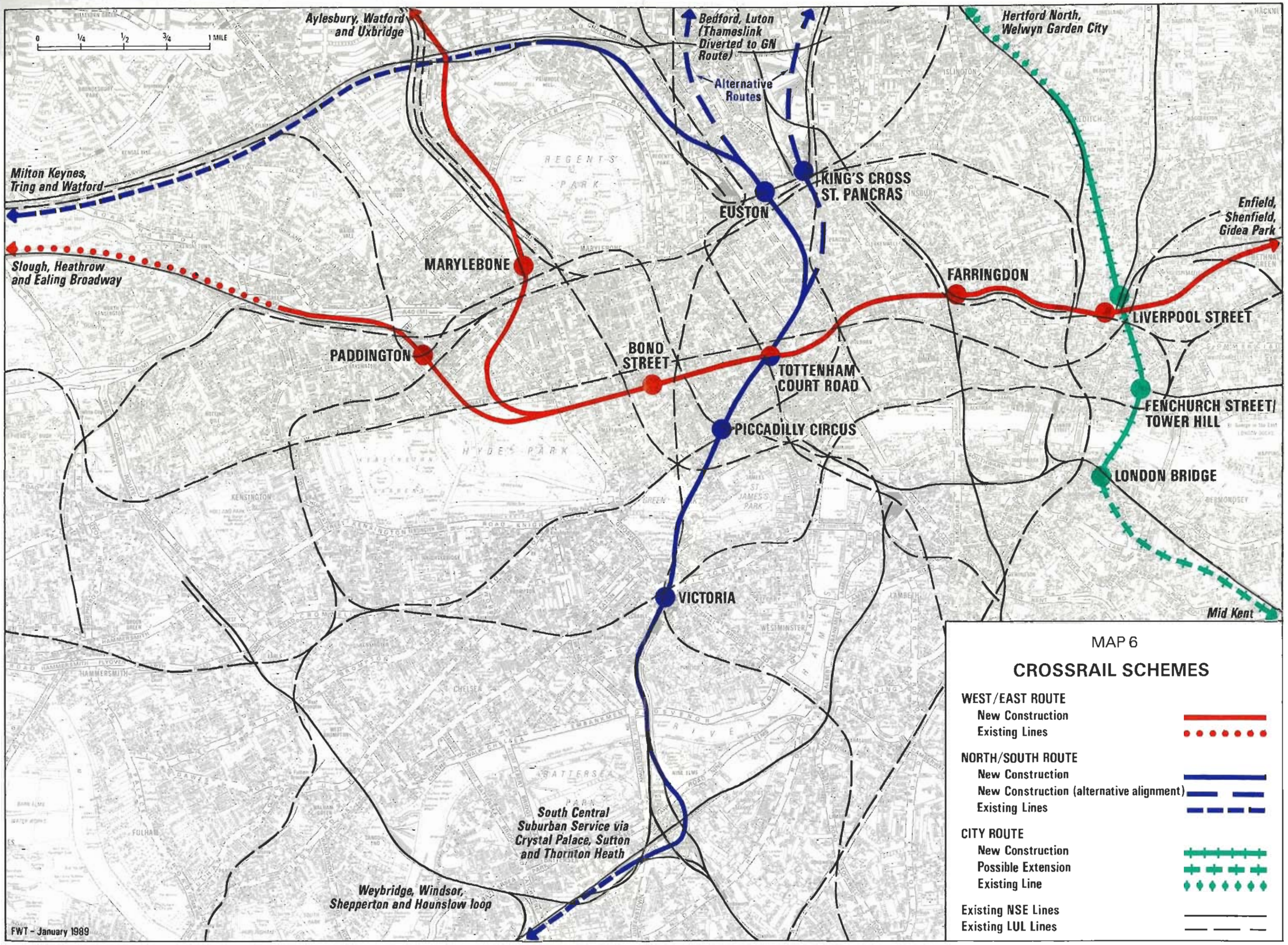
Existing NSE Lines

Existing LUL Lines

Docklands Light Railway


WATERLOO
SOUTHWARK
LONDON BRIDGE
ELEPHANT & CASTLE
SURREY QUAYS
CANARY WHARF
WESTCOMBE PARK
NEW CROSS GATE
LEWISHAM
ALTERNATIVE ROUTES
To West Croydon and Crystal Palace
0 1/4 1/2 3/4 1 MILE
FWT – January 1989
MAP 4
DOCKLANDS SECOND LINE
Waterloo to Canary Wharf / Westcombe Park
BAKERLOO LINE SOUTHERN EXTENSION SCHEME
To LEWISHAM
To CROYDON and CRYSTAL PALACE
Existing NSE Lines
Existing Bakerloo Line
Other Existing LUL Lines
Docklands Light Railway


To West Ruislip
To Harrow & Wealdstone
QUEENS PARK
NORTH ACTON
WEST ACTON
EALING BROADWAY
WORMWOOD SCRUBS
SHEPHERDS BUSH
TURNHAM GREEN
GUNNERSBURY
KEW GARDENS
RICHMOND
0 1/4 1/2 3/4 1 MILE
MAP 5
WEST LONDON SCHEMES
BAKERLOO LINE
Proposed New Link
Existing Central/Future Bakerloo
Unaffected Section
CENTRAL LINE
Proposed New Link
Existing District/Future Central
Unaffected Section
Existing NSE Lines
Other Existing LUL Lines
FWT – January 1989



MAP 6

CROSSRAIL SCHEMES

WEST/EAST ROUTE
- New Construction
- Existing Lines

NORTH/SOUTH ROUTE
- New Construction
- New Construction (alternative alignment)
- Existing Lines

CITY ROUTE
- New Construction
- Possible Extension
- Existing Line

Existing NSE Lines

Existing LUL Lines

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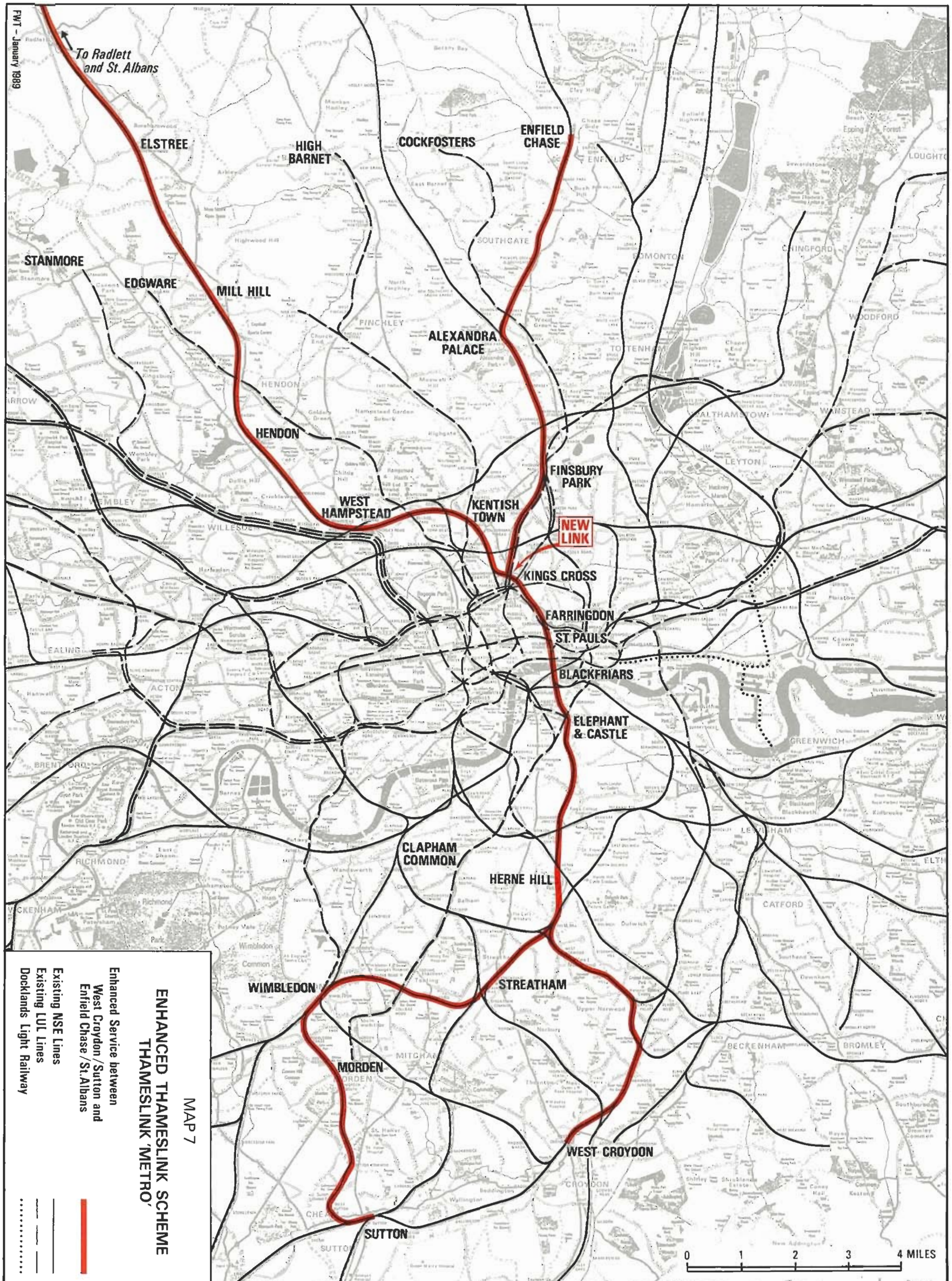

MAP 7

ENHANCED THAMESLINK SCHEME
THAMESLINK 'METRO'

Enhanced Service between West Croydon / Sutton and Enfield Chase / St. Albans

Existing NSE Lines

Existing LUL Lines

Docklands Light Railway